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THE WESTERN PINE BEETLE

A Serious Enemy of Ponderosa Pine

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IMPORTANCE

The western pine beetle (*Dendroctonus brevicomis* Lec.) is the most destructive insect enemy of ponderosa pine (*Pinus ponderosa* Lawson) in the virgin pine forests of California, Oregon, Washington, Idaho, western Montana, and British Columbia. In the United States during the period 1921–45 this beetle, no larger than a grain of rice, killed approximately 2 million trees, or 1 billion board feet of timber, every year. This destruction represents a gross loss of nearly 25 billion board feet of timber, worth 100 million dollars on the stump—more softwood lumber than was produced in the entire United States in 1942, when the lumber industry was "all out" for World War II. In many sections of our forest ponderosa pine stands are no longer con-

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sidered merchantable, because the western pine beetle has already reduced the value of the commercial timber 60 to 90 percent (fig. 1). During recent years losses caused by this beetle have been much less severe: however, the annual drain on our remaining forests is still of such magnitude as to cause real concern to timber owners and conservationists.

Beetle-killed trees deteriorate rapidly and soon become a total loss to the lumberman. Practically all such trees are left in the forest as snags. Until they fall and ultimately rot on the forest floor, these snags add to the ever-present fire hazard in pine-growing regions.

Figure 1.—A beetle-ravaged stand of ponderosa pine. Ghostly snags are mute evidence of an invasion by the western pine beetle. More than 150 years of unmolested growth will be needed before the reproduction in the center foreground replaces the commercial stand killed by the beetles.

Fortunately, the forests themselves, through normal annual growth, offset part of this terrific drain. However, the new growth is of much lower quality because it is mainly in immature trees, whereas losses caused by beetles usually occur in mature and overmature trees containing wood of high quality. Annual growth may compensate for beetle-caused losses over a long period, but during the last two decades it has been equal to only one-third of the annual drain from all causes.

THE BEETLE

The western pine beetle, in common with other beetles, has four distinct stages (fig. 2) in its life cycle. The stage that may be observed in an infested tree depends on the season and the time that elapsed after the attack. The egg (fig. 2, *A*) is white, oval, and about the size of a lead-pencil point. The larva (fig. 2, *B*) is a white,

curved, wrinkled, legless, brown-headed grub, and when mature is about one-fourth inch long. The pupa (fig. 2, *C*), or resting stage, during which the transformation to the adult form takes place, is also white. All the appendages of the adult beetle can be recognized on the pupa. The adult beetle (fig. 2, *D*) is brown to black, cylindrical, rather stout, and is from one-eighth to one-fourth of an inch long.

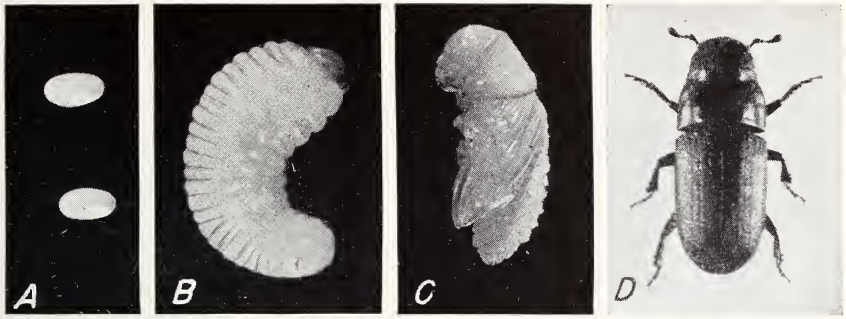

Figure 2.—The four stages of the western pine beetle: *A,* Eggs; *B,* larva; *C,* pupa; *D,* adult. Each 8 times natural size.

WORK AND HABITS

The western pine beetle attacks and breeds primarily in ponderosa pine (*Pinus ponderosa* Lawson) and Coulter pine (*P. coulteri* D. Don.). It has been an inhabitant of the pine forests throughout its present range for hundreds of years.

In an examination of a dead or dying ponderosa pine tree, the real killers, the western pine beetles, often escape detection because they are concealed within the outer corky bark or have completed their development and emerged. The large grubs or beetles commonly found between the bark and wood of these trees are of other species and of only secondary importance. One or more species of pine engraver beetles (*Ips* spp.) and flatheaded borers (*Melanophila* spp.) are sometimes found in the upper part of a tree, and the red turpentine beetle (*Dendroctonus valens* Lec.) sometimes attacks the base before the western pine beetle begins its assault. The interrelationship of these insects is complicated, but the western pine beetle is primarily responsible for the death of the trees it attacks.

How to Recognize an Attack

The western pine beetle attacks only the main trunks of trees with bark sufficiently thick to protect its various stages through their development. It does not breed in limbs or small tops, and seldom attacks trees under 6 inches in diameter.

Upon entering a ponderosa pine stand or viewing a forest from an observation point, one can readily detect the presence of the western pine beetle by differences in the color of the foliage of green and infested trees (fig. 3). The needles of infested trees fade rapidly and progressively from green through the yellows to a red, finally turning sorrel, or reddish brown. They die from the center of the needle cluster outward and usually from the top of the tree down-

Figure 3.—Evidence of a western pine beetle epidemic in progress. Dying and dead ponderosa pines with their characteristic sorrel or red foliage, showing white in this picture, stand out in sharp contrast in a normally green forest.

ward. For several months after a tree has been attacked, the needles are of a sickly green or yellow cast, later becoming red or reddish brown. The third year after attack about 80 percent of the needles drop from the tree, and after the fifth year practically all the needles have been lost.

Fading foliage is an important aid in locating centers of western pine beetle infestation and in identifying dead trees, but it is not altogether a reliable means, because trees attacked by other bark beetles also have fading foliage. However, the fading of the foliage from western pine beetle attack progresses much more rapidly and uniformly than that caused by most other insects.

Whether an attack by the western pine beetle has been successful can best be determined by examining the bark of a suspected tree. If the attack has been successful, small amounts of fine yellow or reddish borings will be lodged in the crevices of the bark or deposited on the ground around the base of the tree. These borings are pushed from the tree through ventilation holes about one-sixteenth of an inch in diameter, made by the attacking beetles. Around or closing the point of entrance of a pair of beetles will usually be found pink or red pitch in the form of a small tube. Trees lacking in vigor or trees that are heavily attacked usually produce inconspicuous "pitch tubes," but on some trees no pitch tubes are produced.

The real evidence of a devastating attack by the western pine beetle is found by removing a section of bark. If a maze of criss-crossing tunnels (fig. 4), tightly packed with reddish borings, is found winding through the cambium layer, the tree is doomed. These tunnels are the egg galleries constructed by the adult beetles, and their

Figure 4.—Proof of attacks by western pine beetles. Egg galleries through the cambium or inner bark are deep, frass-filled channels, and show on the sapwood as tightly packed frass, which adheres to the surface of the wood.

characteristic pattern may be regarded as the sign of the western pine beetle.

Method of Attack

A few beetles cannot kill a tree. It has been estimated that a concentration of 12 pairs of beetles per square foot of bark surface, or about 6,100 beetles, are required to kill an average-sized ponderosa pine. It has been estimated further that enough new beetles are ordinarily produced in a single infested tree to kill 5 other trees of the same size.

For all practical purposes, as soon as a few western pine beetles have started their galleries the tree on which they are working may be considered dead. When the beetles alight on the trunk of a tree, they seek crevices in the bark and bore small round holes directly into the cambium layer. If they encounter too copious a flow of sap or pitch, they may be drowned or "pitched out;" however, if the flow of sap is weak, the beetles are able to continue their boring through the cambium or vital growing layer of the tree. During the summer months it takes only about 14 days for the western pine beetle to kill an average-sized ponderosa pine.

Attacks are begun by the female beetle, and she is joined by the male about the time she reaches the cambium layer. The female constructs practically the entire egg gallery, and deposits her eggs singly in niches cut in the sides of the tunnel as it is being extended. The female excavates about 28 inches of gallery, depositing about 65 eggs. In a normally attacked tree about 11 feet of tunnels are made in each square foot of bark by the various pairs of beetles whose

galleries intermingle. About 55 percent of the attacking beetles emerge, and some construct galleries in a second and possibly a third tree before they die.

The eggs hatch in about 7 days. The tiny larvae bore short tunnels in the cambium at right angles to the main egg gallery, where they feed on the proteins and simple sugars found therein. As they increase in size, they tunnel outward from the cambium and soft inner bark into the corky outer bark (fig. 5.) There they complete their larval development, pass through the pupal stage, and finally emerge as beetles to seek a new host tree. Practically every beetle makes its own emergence hole: so the bark of an abandoned tree appears to have been riddled with bird shot.

Figure 5.—Mature larvae of the western pine beetle. These fat larvae in the outer bark are nearly ready to enter the pupal stage. Usually before they reach this size the foliage of the host tree has faded and the tree has been considered dead.

In killing a tree the beetles appear to be aided by a fungus, *Ceratostomella pini* Munch, belonging to the group of blue-staining fungi. Spores of the fungus, carried into the tree by the attacking beetles, germinate and the hyphae spread rapidly through the conducting vessels and choke them, thus hastening the death of the tree. This fungus gives the blue color to the sapwood of dead trees, a condition that has no other effect on the technical characteristics of the wood.

Seasonal History

In the pine stands of central Oregon, which represent the midrange of the western pine beetle, eggs laid in trees attacked in June and July develop into beetles by August and September. During September and October these new adults attack and kill other trees, in which they and their progeny pass the winter in the egg, larval, or beetle stage. Thus, two sets of trees are killed annually in this area. In years favorable for beetle development, that is, years with a long, warm fall season, a third set of trees may also be killed. This sequence varies, of course, with the latitude and altitude of the forest and the prevailing climatic conditions. Attacks and development occur earlier and extend over a longer period in the southern forests, and later and over a shorter period in the more northern forests.

Types of Infestation

The collective attacks of western pine beetles in a stand or forest are classified as either endemic or epidemic infestations, depending on a quantitative measure of the trees killed and on whether the infested trees grow primarily in groups or as single, scattered trees. Under endemic conditions, when a low or normal population is present, the western pine beetle is highly selective, attacking mostly single trees of poor thrift or injured trees and green windfalls. Losses of this nature constitute a normal expected annual mortality usually amounting to less than 0.5 percent of the total green-pine volume of the stand. Over a period of years under average timber conditions endemic losses are balanced by annual growth.

Under epidemic conditions, when an abnormally high beetle population has built up under favorable circumstances, the beetles are very much less selective with respect to the age and vigor of the trees they attack. By sheer force of numbers they overcome single green trees and large groups of normally healthy trees, causing losses that average well over 0.5 percent of the stand volume. Occasionally as much as 10 percent of a given stand may be killed in 1 year. In one epidemic in Oregon over 200 trees were killed in one group by a simultaneous attack of many beetles; 1,316 trees were killed in 1 year on a single square mile, and instances of the killing of 1,000 or more trees per square mile were not uncommon. Needless to say, losses of such intensity are vastly greater than annual-growth replacement and, unless checked by natural factors or artificial control, soon deplete a forest.

CONTROL

Because the annual depredations of the western pine beetle have remained at a high level for two or three decades, it is evident that the control of this pest has been and still is very difficult. Once a ponderosa pine tree has been successfully attacked by the western pine beetle, there is no known method by which it can be saved. Man, therefore, must rely on natural factors and direct or indirect control measures to protect valuable stands from excessive depletion.

Natural Control

The western pine beetle maintains, and in many years increases, its population notwithstanding the combined effects of many natural factors. Unfavorable climatic conditions, particularly winter air temperatures lower than minus 20° F., maintained for a few days and accompanied by low day temperatures, are periodically helpful in temporarily checking outbreaks. Birds, especially woodpeckers, devour vast quantities of immature beetles, and these birds, in search of food, may nearly strip an infested tree of its bark (fig. 6).

Predaceous clerid and ostomatid beetles are constantly associated with western pine beetle infestations, preying on the mature and immature stages of the beetle. Other predators and several species of parasitic flies and wasps help to reduce populations.

Figure 6.—The work of woodpeckers in search of food. Large quantities of the outer bark of infested ponderosa pine trees are flaked off during the winter by woodpeckers in search of western pine beetle larvae and adults.

Direct Control

In searching for a satisfactory direct method of destroying the western pine beetle, as a supplement to natural control, the Bureau has tried practically all known or suggested measures, ranging from the first simple approach of felling an infested tree and burning the bark to the use of radio waves and electrocution. As a result only two practical methods of direct control can be recommended—the fell-peel-burn method, and control by logging infested trees.

As the name implies, the fell-peel-burn method consists in felling an infested tree, peeling it, and burning the bark (fig. 7). The usual practice is to peel the bark from the upper half or side of the trunk and pile it along the unbarked lower half, and then burn the bark. Limbs, portions of the top, and other inflammable material are usually piled along the trunk to hold the fire and make it hotter. Groups of small infested trees are usually felled, bucked, and decked,

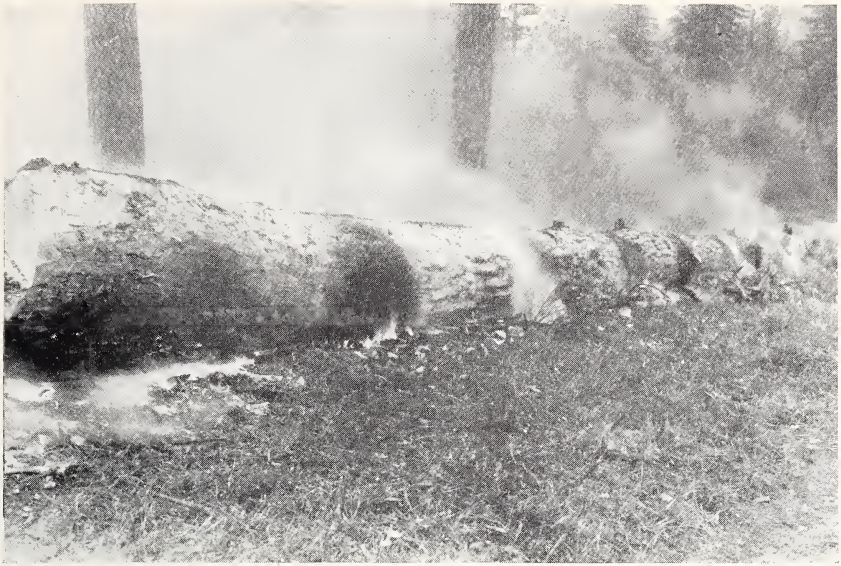

Figure 7.—Death to the western pine beetle. An infested ponderosa pine has been felled, limbed, the bark peeled from the upper portion of the trunk, piled along the trunk, and burned. This is the last step in a fell-peel-burn direct-control project.

and then the entire pile is burned. Because of the forest-fire hazard during the summer months, the fell-peel-burn method is best applied from October 1 to May 1, depending on conditions for burning and working. It has not been economically feasible to rely entirely on this method of control because of the high costs and temporary benefits; however, direct control measures are still practicable, and under careful supervision it is possible to effect drastic reductions in pine beetle populations on a control area for one or more years.

When the western pine beetle is controlled through logging of infested trees, part or all of the control costs are offset by the sale of the salvaged lumber. By this method the infested tree must be removed from the woods before the beetles emerge and the broods must be killed by placing the logs in ponds or by burning the slabs before emergence takes place. The rapid blue-staining of the sapwood soon after attack, with the resulting heavy degrading of the lumber from infested trees, has discouraged the extensive salvage of these infested trees as a control measure. This prejudice against blue-stained lumber is unwarranted, because the fungi that cause the staining do not affect the strength or lasting qualities of the wood.

Indirect Control

The most promising methods of combating the western pine beetle are improved forest-management practices. Recent research by forest entomologists has shown that in any ponderosa pine stand certain types of trees are highly susceptible to attack. It has been found that trees declining in vigor, of slow growth and poor thrift, or top-killed;

trees weakened by overcrowding, fire, or lightning; and, to a lesser extent, those showing signs of overmaturity, are the trees most susceptible to attack. The removal of these trees before they are attacked not only saves a large amount of valuable timber but leaves the stands in a vigorous healthy condition, and better able to resist beetle attacks.

As a result of these studies, two valuable silvicultural tools have been made available to foresters and timber managers to help solve the pine beetle problem. The first is a bark beetle susceptibility classification, referred to as Keen's ponderosa pine tree classification,[2] which recognizes 16 individual classes based on age and vigor. When the more susceptible classes are removed from a mature stand, a cut of 40 to 60 percent of the stand volume usually results. This system has been widely adopted by foresters and timber managers for making selection cuts to remove the trees likely to be killed over a period of 30 to 40 years.

The second tool is a method, devised by Salman and Bongberg,[3] of risk-rating the current health of individual ponderosa pine trees. Four classes of risk to beetle attack are set up, as follows: 1, Low-risk tree—full foliage and healthy appearing crown; needles dark green, long, or coarse; no weakened portions in crown; 2, moderate-risk tree—moderately vigorous crown, imperfect in spots; foliage mostly healthy with fair to good colored needles of average length; few twigs lacking foliage, and few small weakened portions in crown; 3, high-risk tree—crown fair to poor in vigor, somewhat thin and ragged in parts; foliage in parts of crown thin, bunchy, or unhealthy, and of fair to poor color; some to many weakened portions of the crown; 4, very high-risk tree—crown of very poor vigor, ragged, thin, and often showing evidences of active infestation; foliage thin or bunchy; needles short, sparse, or of poor color; some to many twigs and branches dead or dying; large portions of crown weakened (plate 1).

When the trees in classes 3 and 4 are removed by sanitation-salvage logging (a term used to designate this method), the stand volume is reduced by 15 to 30 percent. By removing this high-risk element from the stand bark beetle losses have been reduced, over a 10-year period, by 70 to 85 percent. This type of salvage cutting can be done at costs only slightly higher than the usual utilization cutting.

Thus, through a critical analysis of individual trees in pine stands—their age, vigor, and current health—it is possible to designate the trees likely to be killed by the western pine beetle in either a short or a long period of time. This practice holds much promise for solving the perplexing western pine beetle problem. "Beetle-proof" ponderosa pine forests may sometime become a reality.

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[2] Keen, F. P. ponderosa pine tree classes redefined. Jour. Forestry 41: 249–253, illus. 1943.

[3] Salman, K. A., and Bongberg, J. W. logging high-risk trees to control insects in the pine stands of northeastern California. Jour. Forestry 40: 533–539. 1942.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1951

Risk classes for ponderosa pine:
A, Low-risk tree (class 1); *B,* moderate-risk tree (class 2); *C,* high-risk tree (class 3); *D,* very high-risk tree (class 4).

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